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(54) ALUMINUM ALLOY SHEET EXCELLENT IN PRESS FORMABILITY AND HEM WORKABILITY

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an Al alloy sheet having higher proof stress and moreover having excellent press formability and hem workability for lightening a transport.

SOLUTION: This aluminum alloy material has a compsn. contg., by mass, 0.2 to 1.6% Mg, 0.2 to 1.8% Si and 0.01 to 0.30% Mn, in which the content of Fe is controlled to ≤0.30%, and the balance Al with inevitable impurities, and in which the average crystal particle size of recrystallzed particles in the microstructure after solution heat treatment is ≤45 μm, the average size of Al-Fe and Mg2Si crystallized products is ≤5 μm, furthermore, the average spacing between the crystallized products is ≥20 μm, moreover, the average size of the dispersed particles is 0.02 to 0.8 μm, and the number thereof per unit volume is ≥1 piece/m3.

[Claim 1]Mg: 0.2-1.6% (it is below the same mass%), Si:0.2-1.8%, Mn : while 0.01 to 0.30% is included, It is an aluminum alloy plate which regulates Fe below 0.30% and consists of remainder aluminum and inevitable impurities, An average crystal grain diameter of a recrystallization grain in a microstructure after solution treatment is 45 micrometers or less, While a pitch diameter of an aluminum-Fe system and Mg_2Si crystallized material is below 5 mum, an average interval between these crystallized material is not less than 20 micrometers, And while a pitch diameter of a particulate material is 0.02 - 0.8 mum, the number per unit volume is 1. An aluminum alloy plate excellent in press-forming nature and hem workability being an individual / more than mum^3.

[Claim 2]An aluminum alloy plate which was excellent in press-forming nature according to claim 1 and hem workability which regulated Fe below 0.15% while said

aluminum alloy contained Mn:0.01 -0.15%.

[Claim 3]Said aluminum alloy further Cr:0.01 -0.2%, Zr:0.01-0.2%, V: Including 0.01 - 0.15% of a kind, or two sorts or more, while a pitch diameter of each particulate material of an aluminum-Mn system, an aluminum-Cr system, an aluminum-Zr system, and an aluminum-V system is 0.02 - 0.8 mum, The number per unit volume of total of these particulate materials is 1. An aluminum alloy plate excellent in press-forming nature according to claim 1 or 2 and hem workability which are an individual / more than mum^3.

[Claim 4]An aluminum alloy plate said aluminum alloy excelled [aluminum alloy plate] in press-forming nature and hem workability given in any 1 paragraph of claims 1 thru/or 3 containing Zn:0.005-1.0% and Cu:0.005-1.0% of a kind, or two sorts further.

[Claim 5]An aluminum alloy plate said aluminum alloy excelled [aluminum alloy plate] in press-forming nature and hem workability given in any 1 paragraph of claims 1 thru/or 4 which contain a kind of B:1-300 ppm, two sorts of kinds, or two sorts Ti:0.001-0.1% further.

[Claim 6]An aluminum alloy plate said aluminum alloy excelled [aluminum alloy plate] in press-forming nature and hem workability given in any 1 paragraph of claims 1 thru/or 5 containing Be:0.1-100ppm further.

[Claim 7]Proof stress of an aluminum alloy plate by which hem processing is carried out ($sigma_{0.2}$) An aluminum alloy plate excellent in press-forming nature and hem workability given in any 1 paragraph of claims 1 thru/or 6 which are more than 120-N[/mm] ^{2}.

[Claim 8]An aluminum alloy plate which excelled [proof stress / after paint baking of said aluminum alloy plate] in press-forming nature and hem workability given in any 1 paragraph of claims 1 thru/or 7 which are more than 150-N[/mm] ^{2}.

[Claim 9]Said hem workability is a flexural-center radius (R). Board thickness (t) A ratio (R/t) is 3.0. An aluminum alloy plate excellent in press-forming nature and hem workability given in any 1 paragraph of claims 1 thru/or 8 which are the processability which cannot be broken at the time of the following hem processings.

[Claim 10]3 to which evaluation of said hem workability is specified JIS Z 2204 An item specimen is used, An aluminum alloy plate excellent in press-forming nature according to claim 9 and hem workability which do the bending test of the test piece for bend test by a V-block bend method specified to JIS Z 2248 with a pressing bend method to which it is specified further JISZ 2248, and perform it.

[Claim 11]An aluminum alloy plate which excelled [aluminum alloy plate / said] in press-forming nature and hem workability given in any 1 paragraph of claims 1 thru/or 10 which are the objects for transport airplanes.

[0001]
[Field of the Invention]This invention relates to the Al alloy sheet excellent in press-forming nature and hem workability.

[0002]
[Description of the Prior Art]As the construction of the shell and structural material of transport airplanes, such as a car, a marine vessel, or vehicles, or the object for parts and the structural material of home electronics or the object for parts, roofing, etc., and an object for the members of a structure, AA thru/or JIS5000 AA thru/or JIS 6000 system excellent in a system, a moldability, or baking hardenability (only henceforth 5000 systems thru/or 6000 systems) The aluminum alloy is used. [excellent in the moldability] Also in this, use of the aluminum alloy of 6000 systems is especially considered from a point of said material property or recycling efficiency about a panel material or wheels, such as a door of a car, a fender or a bonnet, etc.

[0003]It is this aluminum-Mg-Si system aluminum alloy in which an aluminum alloy contains Si:0.2-1.8% (it is below the same mass%) and Mg:0.2-1.6% fundamentally 6000 system. and -- this -- 6000 system, an aluminum alloy is aged at the time of the baking finish after press forming, and its proof stress improves, and it can secure required intensity while it secures molding workability according to low proof stress at the time of press-forming processing. When reusing a scrap as an aluminum alloy dissolved raw material, origin [there are comparatively few amounts of alloys] tends to obtain an aluminum alloy ingot 6000 system. Therefore, as compared with the aluminum alloy of 5000 systems with many amounts of alloys, such as the amount of Mg used as an object for transport airplanes from the former, it is advantageous.

[0004]On the other hand, in order to use an Al alloy sheet as the panel for transport airplanes, etc., press-forming processing of deep drawing for making an Al alloy sheet into said member shape, an overhang, bending, an elongation flange, etc. is performed. Under the present circumstances, in deep drawing, an overhang, or stretch flanging, it is high deep drawability. (a marginal contraction ratio and LDR) It is required to secure high shape freezing nature. And press-forming processing conditions are increasingly severe with complication of a product thru/or member shape.

[0005]however, 6000 system, the Al alloy sheet was remarkably inferior in press-forming nature as compared with the steel plate conventionally used for press forming, and was used conventionally -- even if it compares with an Al alloy sheet etc. 5000 system, press-forming nature is inferior. r45 and / whose Al alloy sheet is an r value of 45 degrees or the direction of 90 degree to a rolling direction 6000 system, or r90 -- 0.7 -- as opposed to following being a grade -- 50000 system -- an Al alloy sheet -- r45 and/, or r90 -- 0.8 -- a grade is. [for example,]

[0006]therefore, press-forming nature higher in order to use an Al alloy sheet as a panel material for said transport airplanes 6000 system -- and -- especially -- the inside of press forming -- as the index of a deep-drawing moldability -- marginal diaphragm height (ratio) A high thing is required. And the demand marginal diaphragm depth in said recent-years and deep-drawing shaping is increasingly larger, and is 2.0. High LDR of a more than is needed. For this reason, the Al alloy sheet needs to have a moldability with which it is satisfied of these 6000 system.

[0007]With the outer panel of a car, it is said hem processing (R), i.e., a flexural-center radius, after shaping of deep drawing, an overhang, etc. Board thickness (t) A ratio (R/t) is 3.0. 180 ** bending called the following severe rope hem processings of processing conditions and flat hem processing is performed.

[0008]and it is used conventionally -- as compared with an Al alloy sheet etc., especially an Al alloy sheet tends to produce a crack into the bending portion of a board in this 180 ** bending 6000 system 5000 system. Therefore, 6000 system, in order to apply an Al alloy sheet to the outer panel of a transport airplane, etc., it becomes that a crack does not arise even if it receives severe hem processing of said processing conditions, and indispensable to excel also in the crack nature at the time of bending.

[0009]For the weight saving of transport airplanes, such as a car, while carrying out thinning more, the Al alloy sheet which has higher tensile strength and high proof stress is called for.
These high intensity-ization is the problems of said deep-drawing moldability. (fall of a moldability) It leads to promoting increasingly.

[0010]For this reason, since conditions clear increasingly said press-forming nature which is severe and an Al alloy sheet is applied to said panel of a transport airplane 6000 system, Not only from the side of press-forming art, great efforts to improve the press-forming nature by the side of the raw material of an Al alloy sheet 6000 system are paid from the former.

[0011]Typical art is controlling the chemical composition of an Al alloy sheet 6000 system. For example, as being indicated by JP,64-65243,A, JP,5-291834,A, JP,7-228939,A, etc., It is Si (the amount of superfluous Si) as basic composition of an Al alloy sheet 6000 system. Controlling the amount of Mg or the quantity of crystallized material, such as Mg_2Si, and a gestalt is indicated. Many things for which Cu etc. are added and a moldability is raised are proposed by JP,6-2064,A, JP,6-136478,A, JP,8-109428,A, JP,9-209068,A, JP,9-202933,A, etc.

[0012]the Al alloy sheet surface -- shot dull ** laser -- it rolling with the roll made into the dull finish depended dully, and surface roughening of the dull eye being transferred and carried out to the Al alloy sheet surface, and on it, Many things for which the lubricity in the case of a fabricating operation is raised, and a moldability is raised are

proposed by JP,61-46304,A, JP,63-180331,A, JP,8-168826,A, JP,9-78169,A, etc.

[0013]What is considered as the precoat board which applied beforehand a fluid thru/or solid lubricants, and lubricating oils, such as a wax and resin, to the usual Al alloy sheet surface and said Al alloy sheet surface which carried out surface roughening, A large number are proposed by JP,7-90458,A, JP,7-126785,A, JP,8-168826,A, etc.

[0014]And the process condition was adjusted and the moldability is improved -- adjust wrinkles presser-foot power (BHF), or the press molding method side also uses a hyperviscous oil, or adjusts the coverage of a lubricating oil.

[0015]However, although the method of controlling the amount of Si as basic composition of an Al alloy sheet, the amount of Mg or the quantity of crystallized material, such as Mg_2Si, and a gestalt 6000 system lowers Si and the amount of Mg fundamentally and low proof stress-ization is attained, Said baking hardenability (high-yield-strength-izing) From a point, Si and the amount of Mg which can be reduced have a limit.

[0016]If surely Cu is added, although a moldability will improve, filiform corrosion product-proof **** which is after-paint corrosion resistance deteriorates. That is, more specifically, addition of Cu 0.3% or more knows that filiform corrosion product-proof **** will deteriorate extremely as compared with what does not add Cu.

[0017]Although the method of carrying out surface roughening of the Al alloy sheet surface, or applying lubricant has a fixed effect in improvement in a moldability, it does not have a moldability improved effect which can respond to the severity of the conditions of said press forming.

[0018]And a decisive problem is a point which the crack nature at the time of bendings, such as said hem processing, cannot necessarily improve by improvement art, such as the deep drawability of these former, either.

[0019]Therefore, especially the former 6000 system in an Al alloy sheet. Cannot respond to the severity of the conditions of press forming, but in shaping uses, such as an outer panel of a car. Flexural-center radius (R) The actual condition could not but carry out the design variation to the shape of the flexural-center radius which drops and carries out bending of the efficiency as two or more processes which make small gradually a ratio (R/t) with board thickness (t), etc., or does not produce a crack.

[0020]This bending nature (doubling stretch flanging workability) In order to improve, the local elongation of an Al alloy sheet raw material is raised, and it is board thickness reduction at the time of local deformation. (vena contracta) Various art to control is also proposed. For example, publication number 6 -228690 An item and publication number 6 -228691 in an item gazette. The aluminum-Mg system Al alloy sheet containing 3.5 to 10% of Mg, such as 5000 systems, is made into a core material, and the clad plate which made hide material the aluminum-Mg system Al alloy sheet containing 0.8 to 2.0% of

Mg and the aluminum-Mn system Al alloy sheet containing 0.3 to 4% of Mn, and carried out the clad is proposed.

[0021]Publication number 5 -271836 in an item gazette. While adding Cu for improving strength 0.05 to 0.3% to the aluminum-Mg system Al alloy sheet containing 2 to 10% of Mg, such as 5000 systems, As an impurity element to which local elongation is reduced, they are the following and Fe/Si 0.15% about Si to 0.01 to 0.15% in Fe again 1.4 Controlling below is proposed.

[0022]Publication number 7 -278716 in an item gazette. In the aluminum-Mg system Al alloy sheet containing 2.0 to 6.0% of Mg, such as 5000 systems, as an impurity element to which local elongation is reduced, while making Fe into below and making Si into below 0.15% 0.15%, In order not to degrade mechanical properties, it is indicated that the average size of intermetallic compounds, such as an aluminum-Mg-Si system which remains, and an aluminum-Fe-Si system, shall be 15 micrometers or less.

[0023]
[Problem(s) to be Solved by the Invention]However, the local elongation of these Al alloy sheet raw material is raised, and it is bending nature. (doubling stretch flanging workability) The art to improve, it is the art about an Al alloy sheet 5000 system altogether, and an ingredient, and an organization and the characteristic differ from 5000 systems -- it is inapplicable to an Al alloy sheet as it is 6000 system.

[0024]And said publication number 6 which makes hide material the Al alloy sheet in which local elongation is higher than the Al alloy sheet of a core material, and more specifically carries out a clad -228690 Item, Publication number 6 -228691 Conventional technology like an item gazette is difficult to manufacture the clad plate itself which has the adhesion which is equal to press forming or bending itself. This is because a certain amount of amount of improving strength alloy contents is needed for hide material for press-forming nature, the sex with a crack-proof as a product, or crater nature and an Al alloy sheet interface oxidizes easily by this alloy content in the case of a rolling clad. If these oxidation is prevented and a clad plate is manufactured, a manufacturing cost will soar and it is not practical.

[0025]When [of a core material] the Al alloy sheet of an except is used for an Al alloy sheet 6000 systems as hide material 6000 system, a clad is not carried out even if it makes thickness of hide material thin (single) 6000 system -- it is because the characteristic of high-yield-strength-izing by the low proof stress and baking hardenability at the time of the fabricating operation which is the feature of an Al alloy sheet 6000 system as compared with an Al alloy sheet will surely fall and is not practical too.

[0026]when taking out the characteristics, such as said baking hardenability, Si is included as indispensable 0.8 to 1.8% -- with an Al alloy sheet 6000 system. Said publication number 5 -271836 An item gazette and publication number 7 -278716 Like an item gazette, Si cannot be controlled below 0.15% as an impurity element to which

local elongation is reduced. Intermetallic compounds which control Fe below 0.15% like these conventional technologies, thru/or remain, such as a Mg-Si system and an aluminum-Fe system (crystallized material and particulate material) Making average size small to 15 micrometers or less has the appropriate bending disposition top effect also in 6000 systems. However, according to the place in which this invention persons did knowledge, the bending disposition top effect by these means is very small in an Al alloy sheet 6000 system. Therefore, bending nature in which said hem processing is severe in an Al alloy sheet only by these means at least 6000 system (doubling stretch flanging workability) It cannot have press-forming nature, such as deep drawing which improve, thru/or doubled and was excellent.

[0027]This invention is made paying attention to such a situation, and the purpose tends to provide the Al alloy sheet which has the outstanding press-forming nature and hem workability while having the higher proof stress for the weight saving of a transport airplane.

[0028]
[Means for Solving the Problem]In order to attain this purpose, a gist of this invention, Mg: 0.2-1.6% (it is below the same mass%), Si:0.2-1.8%, Mn : while 0.01 to 0.30% is included, It is an aluminum alloy plate which regulates Fe below 0.30% and consists of remainder aluminum and inevitable impurities, An average crystal grain diameter of a recrystallization grain in a microstructure after solution treatment is 45 micrometers or less, While an average interval between these crystallized material is not less than 20 micrometers while a pitch diameter of an aluminum-Fe system and Mg_2Si crystallized material is below 5 mum, and a pitch diameter of a particulate material is 0.02 - 0.8 mum, the number per unit volume is 1. It shall be an individual / more than mum^3.

[0029]By considering it as said gist, it is the proof stress of an Al alloy sheet at the time of shaping. ($sigma_{0.2}$) Even if it is the high intensity more than 120-N[/mm] ^{2}, The maximum diaphragm depth (LDH_0) is the not less than 25-mm outstanding press-forming nature and a **** flexural-center radius (R). Board thickness (t) A ratio (R/t) is 3.0. Bending nature which cannot be broken at the time of the following hem processings (henceforth hem workability) An Al alloy sheet which it has can be provided.

[0030]The 1st feature of this invention is that it controls a gestalt of an aluminum-Fe system and Mg_2Si crystallized material. The greatest factor in which this invention persons reduce hem workability in an Al alloy sheet of 6000 systems, It is an aluminum-Fe system and Mg_2Si system crystallized material of aluminum-Fe-Si - (Mn, Cr, Zr) etc., a gestalt of this crystallized material is controlled (a size and an interval are regulated) More specifically, the knowledge of hem workability being markedly alike and improving was carried out by regulating a pitch diameter of this crystallized material, and an average interval between crystallized material. As for this, an aluminum-Fe system and Mg_2Si system crystallized material are at the hem processing time. (at and the time of elongation flange processing) Divide. (destruction) Starting point (starting point of a dimple) It is based on knowledge of having become.

[0031]since [however,] it has contributed to an important thing in order that especially Si that constitutes these aluminum-Fe system, Mg_2Si system crystallized material, and this crystallized material may secure intensity required for an Al alloy sheet 6000 system -- simple -- reduction -- or it cannot lose. This point and artificers are controlling a gestalt of these crystallized material that exists by existence thru/or necessity inevitably, and did the knowledge of outstanding hem workability being acquired to reservation of required intensity and press-forming nature. That is, that a set or not shape connected for a long time mutually greatly but detailed crystallized material opens an interval mutually, and these crystallized material that exists during an aluminum alloy organization is distributing carried out the knowledge of contributing to improvement in hem workability.

[0032]And a gestalt of this aluminum-Fe system and Mg_2Si system crystallized material is controlled. (a size and an interval) In order to carry out, Fe as an impurity element usually especially contained in an Al alloy sheet of 6000 systems about 0.15 to 1.0% is regulated below 0.15% preferably hereafter 0.30%. However, Fe is regulated below 0.30% in this case, and in a request, while a pitch diameter of an aluminum-Fe system and Mg_2Si crystallized material is 5 micrometers or less, an average interval between these crystallized material is not not less than 20 micrometers. That is, for regulation of a size of this aluminum-Fe system and Mg_2Si crystallized material, and an interval, the knowledge also of casting mentioned later, rolling, and selection of solution-heat-treatment quenching treatment conditions also becoming important was carried out.

[0033]For example, said publication number 7 -278716 [gestalt control of crystallized material like an item gazette], i.e., only [it makes small mean particle diameter of crystallized material of a casting material], it does not contribute to improvement in hem workability mostly. In other words, this invention persons are said publication number 7. -278716 Against thought like an item gazette, as it is, even if mean particle diameter of crystallized material of a metaphor Al alloy sheet organization is large, It opens an interval and is distributing. (it exists sparsely) When becoming, the knowledge of contributing to improvement in hem workability was carried out. That is, even if particle diameter of crystallized material is small, in a state thru/or the state where it was connected which crowded small, a mutual interval serves as a starting point of destruction, and degrades hem workability. Of course, in this invention, an aluminum-Fe system and the Mg_2Si crystal amount itself are reduced except a part which secures required intensity and a moldability.

[0034]And by this invention, a pitch diameter of crystallized material and an average interval between these crystallized material are chosen as an index which corresponds to control of this crystal amount, and a situation which crystallized material opens an interval mutually and is distributing (a mutual interval of crystallized material is not in a state which crowded small thru/or a connected state) well.

[0035]Next, the 2nd feature of this invention is the point of making a particulate material of an aluminum-Mn system, an aluminum-Cr system, an aluminum-Zr system, and an aluminum-V system existing positively during an organization. In order to prevent big

and rough-ization of recrystallization particle diameter at the time of solution treatment and to carry out minuteness making of the recrystallization particle diameter in this invention, particulate materials, such as an aluminum-Mn system, are made to exist positively during an organization, and it is big and rough-ization of a recrystallization grain. (grain growth) The pinning effect to inhibit is demonstrated. And as a result, minuteness making of the recrystallization particle diameter after solution treatment is carried out to 45 micrometers or less with an average crystal grain diameter required in order to control reservation of press-forming nature, and generating of orange peel.

[0036]By making particulate materials, such as an aluminum-Mn system, exist positively during an organization, local elongation of material can be increased and hem workability can be raised. As described above, when Fe is regulated below 0.30%, recrystallization particle diameter at the time of solution treatment is [become] easy to tend become big and rough. On the other hand, existence of particulate materials, such as an aluminum-Mn system, is effective also from a point which controls this tendency.

[0037]
[Embodiment of the Invention](An aluminum-Fe system and Mg_2Si crystallized material) Next, regulation of the crystallized material in this invention is explained. In this invention, for the improvement in hem workability, while the pitch diameter of the aluminum-Fe system and Mg_2Si crystallized material of the Al alloy sheet organization after solution treatment is below 5 mum, the average interval between these crystallized material may be not less than 20 micrometers.

[0038]Although there are various kinds with alloy composition, the crystallized material which consists of aluminum-Fe-Si - (Mn, Cr, Zr) generated mainly at the time of casting makes aluminum-Fe system crystallized material the object of control by this invention. The Mg_2Si crystallized material generated below with a solution treatment temperature at processes, such as aluminum-Fe system crystallized material and casting, this hot-rolling, solution treatment, A pitch diameter exceeds 5 mum or the average interval between these crystallized material in less than 20 micrometers. Proof stress of the Al alloy sheet at the time of shaping ($sigma_{0.2}$) In the case of the high intensity more than 120-N[/mm] ^{2} etc., Flexural-center radius (R) Board thickness (t) A ratio (R/t) is 3.0. The hem workability that it cannot divide at the time of the following hem processings falls, and it has only the hem workability of the conventional 6000 system aluminum alloy average.

[0039]Measurement of the pitch diameter of these aluminum-Fe system crystallized material and Mg_2Si crystallized material, and the average interval between these crystallized material, 500 of the organization of the parallel section of an Al alloy sheet In order to take into consideration the variation in the construction material of an Al alloy sheet by a twice as many scanning electron microscope (SEM) as this, visual observation of measurement point 20 arbitrary views of an Al alloy sheet thru/or the average of an image-analysis audit observation perform. A measured region is performed in each position which divided from the surface of a board to the board central part into 20 equally. The path of the crystallized material said by this invention means the greatest length of each crystallized material particle which can be measured with said each view.

And with the pitch diameter of the crystallized material said by this invention, measure the greatest length of all aluminum-Fe system crystallized material which can be measured with said each view, and Mg_2Si crystallized material particles, and total of this length between couplings is **(ed) by the number of crystallized material, 1 The average value of the length between couplings of the crystallized material per view should be calculated, and the average value of the average length between couplings in each of this view should be further average-value-ized with 20 views again.

[0040]Square [which is measured with each view / a number of crystallized material particles of] are computed, and it is referred to as A, next the interval between the crystallized material said by this invention is the area of each view. (micrometer^2) Square was computed, it should be referred to as B and the interval between crystallized material should be computed as B/(A+1). And with the average interval between the crystallized material said by this invention, said computed B/(A+1) should be average-value-ized with 20 views.

[0041](Particulate material) The particulate material said by this invention means the particulate material of an aluminum-Mn system, an aluminum-Cr system, an aluminum-Zr system, and an aluminum-V system. In order to prevent big and rough-ization of the recrystallization particle diameter at the time of solution treatment in this invention as described above, case there is much content of the particulate material of an aluminum-Mn system and Mn, Cr, Zr, and V at basic composition (when it adds positively, thru/or there is much quantity as an impurity) ****. Fine dispersion of the particulate material of an aluminum-Mn system, an aluminum-Cr system, an aluminum-Zr system, and an aluminum-V system is positively carried out during an organization, and it is big and rough-ization of a recrystallization grain. (grain growth) The pinning effect to inhibit is demonstrated. And as a result, an average crystal grain diameter carries out minuteness making of the recrystallization particle diameter after solution treatment to 45 micrometers or less. By making a particulate material exist positively during an organization, the local elongation of material is increased and hem workability is raised.

[0042]In order to demonstrate this effect, while the pitch diameter of a particulate material is 0.02 - 0.8 mum, the number per unit volume is 1. It is required to be an individual / more than mum^3. When two or more particulate materials of an aluminum-Mn system, an aluminum-Cr system, an aluminum-Zr system, and an aluminum-V system are intermingled, the number per unit volume is specified as total of each intermingled particulate material about each particulate materials of all intermingled about the pitch diameter of said particulate material.

[0043]That this particulate material considers it as the object of control by this invention although there are various kinds with alloy composition, $_3SiAl_{12}$ which is a particulate material generated at the time of uniformity heat treatment, and becomes main by an aluminum-Mn system (Fe, Mn), (Fe, Mn) By the aluminum$_3$Zr [which becomes main by the aluminum$_6$, aluminum$_{12}Mg_2$ / which becomes main by an aluminum-Cr system / Cr and aluminum-Zr system], and aluminum-V system, they are particulate materials, such

as AlV which becomes main.

[0044]Said each effect is not demonstrated [the pitch diameter of these particulate materials] for less than 0.02 micrometer and the number per unit volume by less than one piece / mum^3. If the pitch diameter of these particulate materials exceeds 0.8 mum, on the contrary, at the time of press forming or hem processing, it will become a starting point of destruction and a moldability will be reduced.

[0045]Measurement of the pitch diameter of these particulate materials, and the number per unit volume, Board thickness 1/4 of an Al alloy sheet The sample for observation is extracted from a part (L-LT side), and in order to take into consideration the variation in the construction material of an Al alloy sheet of 5000 times as many transmission electron microscopes (TEM), visual observation of measurement point 10 arbitrary views of an Al alloy sheet thru/or image-analysis observation perform.

[0046]Here, the path of the particulate material said by this invention means the greatest length of the particulate material of an aluminum-Mn system, an aluminum-Cr system, an aluminum-Zr system, and an aluminum-V system. With and the pitch diameter of the particulate material said by this invention. The greatest length of all these [which can be measured with said each view] particulate materials is measured respectively, total of this greatest length is **(ed) by the number of particulate materials, and it is 1. The average value of the length between couplings of the particulate material per view should be calculated, and the average value of the length of further the average maximum in each of this view should be again average-value-ized with ten views.

[0047]the number per unit volume said by this invention (density of a particulate material) . It is volume [of each view] V ($micrometer^3$) [sample path length of area ($micrometer^2$) x each view of V= each view (micrometer)] about the number of the particulate materials of the aluminum-Mn system counted with each view, an aluminum-Cr system, an aluminum-Zr system, and an aluminum-V system. It divides and is considered as the number per unit volume.

[0048]The test sample which carried out the thinning of the measurement by said transmission electron microscope to about 0.1-mm thickness by mechanical polishing, Electrolytic polishing (jet polish) The part where 0.1 - 0.3 mu m (1000-3000A) thin-film-ized thickness of the observation part locally is observed with a transmission electron microscope, and is performed.

[0049](Recrystallization particle diameter) In this invention, minuteness making of the recrystallization particle diameter after solution treatment is carried out to 45 micrometers or less with an average crystal grain diameter required in order to control reservation of press-forming nature, and generating of orange peel as described above. That is, when it becomes big and rough exceeding 45 micrometers with an average crystal grain diameter, while press-forming nature falls, generating of orange peel etc. is caused.

[0050]The line intercepting method estimated measurement of recrystallization particle diameter in the rolling direction. Namely, tetrafluoro way acid after carrying out mechanical polishing of the surface of an Al alloy sheet to 0.05-0.1 mm: Water =15: In the solution of 400, With the 50 times as many optical microscopes (TEM) which carried out electrolytic etching in voltage 30V, solution temperature [of 20-30 **], and time 60 to 90 seconds, and use a polarizing plate. In order to take into consideration the variation in the construction material of an Al alloy sheet, visual observation of measurement point 10 arbitrary views (with 5 book, the line length per 1 book is 500 mum per one view) of an Al alloy sheet performs.

[0051]the example of an invention of the example mentioned later -- an Al alloy sheet carrying out solution treatment 6000 system, and, The pitch diameter of **aluminum-Fe system crystallized material and Mg_2Si crystallized material of the microstructure in the thickness direction cross section after hardening, and the average interval between these crystallized material, 500 measurement of 20 views by a twice as many scanning electron microscope (SEM) as this -- and, ** According to measurement of 20 views by a 5000 times as many transmission electron microscope (TEM) as the pitch diameter of particulate materials, such as an aluminum-Mn system, and the number per unit volume. ** Below 5 mum had [aluminum-Fe system crystallized material and Mg_2Si crystallized material] the detailed pitch diameter, and it is not less than 20 micrometers, and the average interval between these crystallized material opened the interval mutually, and was distributing it finely. The number per unit volume was distributing the pitch diameter of particulate materials, such as **aluminum-Mn system, to more than one piece / mum^3, and homogeneity while it was detailed at 0.02 - 0.8 mum. As for the particle diameter of the recrystallization grain after solution treatment, minuteness making of the average crystal grain diameter was carried out to 45 micrometers or less.

[0052]On the other hand, the former measured like the above 6000 system in an Al alloy sheet. Minuteness making of the particle diameter of the recrystallization grain after solution treatment is carried out to 45 micrometers or less by the average crystal grain diameter, and aluminum-Fe system crystallized material and Mg_2Si crystallized material, It is less than 20 micrometers and, moreover, as for the average interval between the crystallized material of a detailed thing, crystallized material was carrying out aggregate-izing thru/or shape where joined together and crystallized material was connected for a long time.

[0053]and said this invention -- the passage of the example which an Al alloy sheet mentions later 6000 system -- artificial aging (paint printing) While having the high intensity more than 160-N[/mm] ^{2} by next $sigma_{0.2}$, a hem workability owner is carried out to the outstanding press-forming nature. On the other hand, there is said conventional difference with both remarkable in hem workability 6000 system in which hem workability is notably inferior in an Al alloy sheet. Therefore, even if it does not contribute to improvement in hem workability mostly only by making small mean particle diameter of the crystallized material of an Al alloy sheet 6000 system but the mean particle diameter of metaphor crystallized material is large as it is, It opens an interval and is distributing. (it exists sparsely) If it becomes, it will be proved that the Al

alloy sheet which was excellent in hem workability is obtained.

[0054]Other crystallized material and sludges are also explained. Things typical as other crystallized material and sludges are crystallized material $aluminum_2Cu_2Mg$ of $aluminum_7Cu_2$ Fe when the sludge of Si simple substance and Cu contain mostly, and also a compound phase with aluminum of Cu or Mg, $aluminum_2Cu_2$, etc., for example.

[0055]If especially the sludge of Si simple substance deposits and exists on a grain boundary, it will serve as a starting point of material destruction, and will reduce hem workability remarkably. Therefore, as for the sludge of Si simple substance, it is preferred to exist in the range which does not exist substantially on a grain boundary or does not check the various characteristics of this invention Al alloy sheet. However, when it manufactures in the desirable presentation mentioned later and the range of a manufacturing method, by the time the sludge of Si simple substance has an adverse effect on the characteristic, it will not deposit on a grain boundary.

[0056]Also about crystallized material, such as other $aluminum_7Cu_2$ Fe or $aluminum_2Cu_2Mg$, and $aluminum_2Cu_2$, if it exists on a grain boundary, it will become a starting point of material destruction and hem workability will be reduced remarkably. Therefore, it is preferred to reduce such quantity. However, these crystallized material has little absolute magnitude as compared with the quantity of said aluminum-Fe system crystallized material, and moreover, if gestalt control of the aluminum-Fe system crystallized material is carried out as mentioned above, in connection with this, quantity can reduce it inevitably to the range which does not influence hem workability. Therefore, this invention does not prescribe crystallized material in particular other than said aluminum-Fe system or Mg_2Si crystallized material.

[0057](Chemical composition of this invention aluminum alloy) Next, the chemical composition in this invention aluminum alloy is explained. The aluminum alloy of this invention needs to satisfy the characteristics, such as mechanical properties, such as intensity as transport-airplane material, a structural material, or the objects for parts, such as a car and a marine vessel, and elongation, corrosion resistance, stress-corrosion-cracking nature or recycling efficiency with few amounts of alloys. Among this, the tensile strength of the Al alloy sheet by which press forming is carried out fundamentally especially as a panel material of a car More than 270-N[/mm] ^{2}. Proof stress ($sigma_{0.2}$) It is below 140-N[/mm] ^{2}, and it is preferred that the proof stress after paint baking is more than 180-N[/mm] ^{2} preferably in more than 160-N[/mm] ^{2}.

[0058]Therefore, as for the chemical composition of this invention aluminum alloy, in order to satisfy said various characteristics, an aluminum-Mg-Si system is an ingredient standard of an aluminum alloy 6000 system. (6101, 6003, 6151, 6061, 6N01, 6063, etc.) It shall correspond. However, 6000 system, in accordance with regulation of the content of each of following elements, in order to add improvement in the further characteristic, and other characteristics, as for change of component composition, it approves suitably even if not as each ingredient standard of an aluminum alloy. It is permitted that change of the component range of this point and the above-mentioned element and other

elements which do not have a statement in the following, such as nickel, Sc, Ag, and Sn, corresponding to a more concrete use and demand characteristics are included suitably. It approves in the range in which other impurities mixed inevitably prevent neither quality nor the characteristic from gas constituents, dissolved raw material scraps, etc., such as H_2 and O_2.

[0059]However, if a hydrogen content increases exceeding 0.5 cc / 100g aluminum, in a manufacturing process, porosity, and a blister and a blister will occur in an Al alloy sheet, and various characteristics including press-forming nature or hem workability, such as the moldability of an Al alloy sheet, will be reduced. Therefore, below 0.5 cc/100g aluminum makes a hydrogen content desirable.

[0060](The amount of elements of this invention aluminum alloy) Next, significance of critical range and the desirable range are explained about the content of each element of this invention aluminum-Mg-Si system Al alloy sheet which satisfies said characteristic.

[0061]Mg: 0.2 to 1.6%. Mg is artificial aging. (shaping, printing curing treatment after paint, etc.) It deposits as Mg_2Si with Si, and Cu, aluminum, and a compound phase are further formed in Cu content presentation, and it is the high intensity at the time of final product use. (proof stress) It is an indispensable element in order to give. In content of less than 0.6% of Mg, the amount of work hardening falls and the high intensity more than 160-N[/mm] ^{2} is not obtained by $sigma_{0.2}$ artificial aging. On the other hand, it is intensity when contained exceeding 1.6%. (proof stress) It becomes high too much and a moldability is checked. Therefore, content of Mg is taken as 0.6 to 1.6% of range.

[0062]Si: 0.2 to 1.8%. With Mg, Si also deposits as Mg_2Si by artificial aging treatment, and it is the high intensity at the time of final product use. (proof stress) It is an indispensable element in order to give. In less than 0.8% of content of Si, intensity sufficient by artificial aging is not obtained and the high intensity more than 160-N[/mm] ^{2} is not obtained by $sigma_{0.2}$. On the other hand, if contained exceeding 1.8%, it will deposit as simple substance Si grain big and rough at the time of casting and quenching, and a moldability and toughness will be reduced. It is easy to make an aluminum-Fe system and Mg_2Si crystallized material big and rough, and it becomes difficult to make the pitch diameter of this crystallized material and the average interval between crystallized material below into regulation. As a result, it is a flexural-center radius (R) especially. Board thickness (t) A ratio (R/t) is 3.0. The crack nature at the time of the following hem processings is reduced. That toughness and elongation become low etc. also checks a moldability. Therefore, content of Si is taken as 0.8 to 1.8% of range.

[0063]Fe: 0.30% or less. Fe inevitably contained as an impurity in an aluminum alloy tends to generate the big and rough aluminum-Fe system crystallized material made into a problem by this invention. Hem workability, press-forming nature, etc. are degraded as it described above, when these crystallized material became big and rough. Usually, the content of Fe as an impurity is 0.15% - about 0.3%. However, if the content of Fe exceeds 0.15% especially more severely 0.30%, it will become difficult to become easy to make aluminum-Fe system crystallized material big and rough, and it to make below

regulation the pitch diameter of this crystallized material and the average interval between crystallized material. Therefore, the content of Fe is so preferred that it is low, and is more preferably regulated in the following smallest possible quantity 0.15% 0.30% or less.

[0064]Mn: 0.01 to 0.30%. Mn is required in order to make an aluminum-Mn system particulate material generate. In order to prevent big and rough-ization of the recrystallization particle diameter at the time of solution treatment in this invention as described above, fine dispersion of the aluminum-Mn system particulate material is carried out during an organization, and it is big and rough-ization of a recrystallization grain. (grain growth) The pinning effect to inhibit is demonstrated. The local elongation of material is raised by carrying out fine dispersion of the aluminum-Mn system particulate material during an organization. For the purpose, while the pitch diameter of an aluminum-Mn system particulate material is 0.02 - 0.8 mum, the number per unit volume is 1. It is required to be an individual / more than mum^3. And in order to carry out gestalt control of the aluminum-Mn system particulate material in this way, content in the range of 0.01 to 0.15% of low level is preferably required 0.01 to 0.30% in Mn. The effect which the absolute number of an aluminum-Mn system particulate material is insufficient for the content of Mn by the following 0.01%, and said pinning effect is insufficient, and controls big and rough-ization of a recrystallization grain, and the effect of raising the local elongation of material are lost. 0.30%, if more severely contained exceeding 0.15%, it will be easy to generate an intermetallic compound big and rough at the time of the dissolution and casting, will become a starting point of the destruction at the time of shaping, and will become the cause of reducing a moldability on the contrary.

[0065]Cr: 0.01 -0.2%, Zr: 0.01 to 0.2%, and V:0.01 - 0.15% of a kind, or two sorts or more. These elements are elements which are made to form a particulate material like Mn and are made to contain selectively for the minuteness making of a recrystallization grain, or the improvement in hem workability. These elements are particulate materials, such as AlV, as an $aluminum_3Zr$ and aluminum-V system as an $aluminum_{12}Mg_2$ Cr and aluminum-Zr system as an aluminum-Cr system at the time of hot working, such as hot-rolling of the time of uniformity heat treatment, and after that. (disperse phase) It generates. And since these generation particulate material has the pinning effect which bars the grain boundary migration after recrystallization like said Mn, it can acquire a detailed recrystallization grain. The amount of minimums of these elements cannot demonstrate this effect respectively for said less than numerical value. However, superfluous content tends to generate an intermetallic compound big and rough at the time of the dissolution and casting, serves as a starting point of the destruction at the time of shaping, and becomes the cause of reducing moldabilities, such as hem workability, on the contrary. Superfluous content of Zr makes a rolling direction carry out the shape of needle length of the recrystallized structure, and degrades the fracture toughness and the fatigue characteristics, and also the moldability of a specific direction. for this reason, the maximum of the content of these elements -- each, Cr:0.2%, and Zr: -- it carries out the following V:0.15% 0.2%.

[0066]Cu: 0.1-1.5%, Zn: 0.005 to 1.0% of a kind, or two sorts. Both Cu and Zn are elements made to contain selectively, in order to form a compound phase, to deposit and to raise intensity. Among this, Cu contributes to improvement in the intensity of an organization, and also on the occasion of aging treatment, carries out uniform dispersion of the sludge minutely, and has an effect which promotes artificial-aging hardening of a final product remarkably. It also has the effect of raising press-forming nature. An effect will be saturated, if the content of Cu does not have these effects and exceeds 1.5% in less than 0.1%. If the content of Cu exceeds 1.5%, corrosion resistance, such as thread-proof rust nature, and weldability will fall notably. Therefore, the content of Cu may be 0.1 to 1.5%.

[0067]At the time of artificial aging, Zn deposits $MgZn_2$ minutely and with high density, and realizes high intensity. Room temperature prescription is controlled, however intensity sufficient in content of less than 0.005% of Zn at artificial aging is not obtained, but on the other hand, if contained exceeding 1.0%, corrosion resistance will fall notably. Therefore, as for the content of Zn, it is preferred to consider it as 0.005 to 1.0% of range.

[0068]Ti: A kind (0.001 to 0.1%, and B:1-300 ppm), or two sorts. Ti and B carry out minuteness making of the crystal grain of an ingot, are an element which raises press-forming nature, and are made to contain it selectively. Among this, by less than 0.001% of content, this effect is not acquired, but on the other hand, if Ti contains Ti exceeding 0.1%, it will form big and rough crystallized material, and will reduce a moldability. Therefore, as for the content of Ti, it is preferred to consider it as 0.001 to 0.1% of range.

[0069]In content below 1 ppm, this effect is not acquired, but on the other hand, if B is contained exceeding 300 ppm, it will form too big and rough crystallized material, and will reduce a moldability. Therefore, as for the content of B, it is preferred to consider it as the range of 1-300 ppm.

[0070]Be: 0.1-100 ppm. Be is an element made to contain selectively, in order to prevent reoxidation of aluminum molten metal in the air. However, in content below 0.1 ppm, this effect is not acquired, but on the other hand, if contained exceeding 100 ppm, material hardness will increase and a moldability will be reduced. Therefore, as for the content of Be, it is preferred to consider it as the range of 0.1-100 ppm.

[0071]Next, the manufacturing method of the Al alloy sheet of an aluminum-Mg-Si system in this invention is explained. Although the Al alloy sheet of an aluminum-Mg-Si system in this invention can be fundamentally manufactured with a conventional method, there are also desirable conditions for the improvement in the characteristic. First, in this invention aluminum alloy ingredient standard range, for example, the usual dissolution casting processes, such as the continuous casting rolling method and a semi-continuous casting method (direct chill casting process), are chosen suitably, and the aluminum alloy molten metal by which dissolution adjustment was carried out is cast. Subsequently, uniformity heat treatment is performed to this aluminum alloy ingot, after hot-rolling and necessity are accepted, and it is intermediate annealing. (rough annealing) After carrying out, it cold-rolls with 1 time or two or more paths, condition-ized processing and

hardening are performed eventually, and it is considered as the product sheet of desired board thickness.

[0072]As for a product sheet, as occasion demands, surface treatments, such as washing thru/or cleaning processing of alkali, acid, etc., chromate, and Zn plating, are performed. It is also possible to omit said intermediate annealing or to omit cold rolling for low-cost-izing. Next, the desirable conditions for the improvement in the characteristic of a product sheet are explained.

[0073]** Although the one where the cooling rate of an ingot is larger is preferred about dissolution casting for the minuteness making of the crystal grain of an aluminum alloy casting material, in order to control the average interval between said crystallized material, the one where a cooling rate is larger is not necessarily good. That is, if the cooling rate of an ingot is too large, much detailed crystallized material will deposit, density will become large, and the average interval between said crystallized material may become small, and may separate from regulation of this invention. therefore, the cooling rate of an ingot -- aluminum alloy presentation from the cooling rate at 0.05 **/sec or more (precipitation amount of crystallized material) every -- and it is necessary to choose from the relation between the minuteness making of said crystal grain, and the average interval between said crystallized material strictly

[0074]** Rank second and it is this aluminum alloy ingot. (casting material) Although uniformity heat treatment is carried out by 450 - 540 **, it is preferred to carry out uniformity heat treatment at the temperature more than 500 **. Although the usual uniformity heat treatment temperature of this seed aluminum alloy casting material is a 480 - 510 ** grade, this invention -- as [said] having carried out -- Mn -- or -- in addition -- making a kind of Cr, Zr, and V, or two sorts or more contain -- the time of uniformity heat treatment -- particulate materials, such as an aluminum-Mn system particulate material, aluminum$_{12}$Mg$_2$ Cr, aluminum$_3$Zr, and AlV system (disperse phase) It is made to generate. For the purpose, uniformity heat treatment in an elevated temperature is preferred, and it is preferred that more than 510 ** makes uniformity heat treatment temperature into the temperature below a melting temperature. Also in order to enlarge the average interval at the time of dissolving as much as possible and crystallizing an aluminum-Fe system and Mg_2Si crystallized material crystallized material, it is preferred to make uniformity heat treatment temperature into the temperature more than 510 **.

[0075]** They end rolling above 200 ** while, as for the conditions of hot-rolling after uniformity heat treatment, below uniformity heat treatment temperature carries out rolling starting temperature as usual.

[0076]However, for low-cost-izing of an Al alloy sheet, moreover it omits and cold-rolls intermediate annealing after hot-rolling, intermediate annealing and cold rolling may be omitted depending on the case, and an aluminum alloy hot-rolling board may be used as a product sheet. Therefore, in order to prevent the RIJINGU mark at the time of press-forming processing thru/or the crack at the time of bending in such a case, it is aluminum

alloy hot-rolling. (as) It is desirable to make the organization of a board into a homaxial-like recrystallization grain with a particle diameter of 50 micrometers or less. for this reason -- being alike -- the rolling reduction [in / at least / a latter path thru/or rolling stand] of heat finishing rolling which consists of two or more rolling stands as the bottom of the above high voltage 50%, And it is more than recrystallizing temperature about hot-rolling finish temperature. (recrystallizing temperature serves as the range of 300 - 450 ** in general) Carrying out is preferred. As for hot-rolling starting temperature, it is preferred to consider it as 450 - 540 **, considering hot-rolling finish temperature.

[0077]Since the degree of location of the cube direction of a homaxial-like recrystallization grain is improved and the minuteness making also of the particle diameter of a macro crystal grain can be carried out to 1.5 mm or less by the hot-rolling conditions of this, it also becomes possible to prevent the RIJINGU mark in the case of press forming.

[0078]** Intermediate annealing: As for the organization of an Al alloy sheet, it is [sake / on a press-forming disposition] preferred to eliminate the anisotropy by the fibrous processing organization thru/or rolling organization which elongates to a rolling direction, and to consider it as a detailed homaxial-like recrystallization grain with a particle diameter of 50 micrometers or less. Since the moldability of an Al alloy sheet falls so that there are many said processing organizations thru/or rolling organizations, the improvement in the moldability of an Al alloy sheet relates to the ability to be made [which] into a detailed homaxial-like recrystallization grain. However, intermediate annealing after hot-rolling may be omitted for low-cost-izing of an Al alloy sheet as described above.

[0079]By the usual hot-rolling, it is aluminum alloy hot-rolling. (as) The organization of the board is said processing organization thru/or a rolling organization, and is taken as a homaxial-like recrystallization grain by intermediate annealing after hot-rolling this. The microstructure with the rear end part of the coil which hits the end part of the microstructure of the tip part of a coil which is equivalent to the start part of hot-rolling, and hot-rolling, Regular part performed by stabilizing hot-rolling (center section of the coil) Since the characteristics of a product Al sheet differ easily within a board thru/or a coil, it can uniform differing from a microstructure etc. by carrying out intermediate annealing of this. It also becomes possible to prevent the RIJINGU mark in the case of press forming as described above by considering it as a detailed homaxial-like recrystallization grain with a particle diameter of 50 micrometers or less.
[0080]desirable intermediate-annealing conditions for this -- up to annealing temperature -- a part for 30 **/-, and 2000 **/-- carrying out rapid heating with the heating rate more than a second, and holding with the annealing temperature of 500 - 580 ** for 10 seconds - 10 minutes -- furthermore -- from retention temperature up to 50 ** -- a part for 30 **/-- the above -- quenching is preferred.

[0081]** While considering it as a desired product sheet thru/or product coil thickness in cold rolling, it is a micro crystal grain. (the usual crystal grain) In order to be referred to as 45 micrometers or less and to raise press-forming processability, it is preferred to

consider a cold rolling rate as the above 50%. Rolling of this cold rolling rate is cold-rolled with 1 time or two or more paths, condition-ized processing and hardening are performed eventually, and it is considered as the product sheet of desired board thickness.

[0082]** Final solution heat-treatment: Solution heat treatment and hardening treatment, The average crystal grain diameter of the recrystallization grain in the microstructure after processing sets to 45 micrometers or less, While below 5 mum carries out the pitch diameter of an aluminum-Fe system and Mg_2Si crystallized material, the average interval between these crystallized material shall be not less than 20 micrometers, And while below 0.02 - 0.8 mum carries out the pitch diameter of particulate materials, such as an aluminum-Mn system, the control which makes the number per unit volume more than one piece / mum^3 is governed. Solution treatment the heating rate to solution treatment temperature using continuous annealing furnaces, such as CAL, a part for therefore, 10 **/, desirable -- a part for 30 **/-- the above -- carrying out rapid heating -- after 530 to 580 **several seconds - 10-minute maintenance, and from retention temperature up to 30 ** -- a part for 30 **/-- more than -- quenching with a cooling rate is preferred. However, even if it is this desirable condition within the limits, especially, a crystallized material generation situation may change according to chemical composition and the production histories till then, such as quantity of Cu or Si, and the solution treatment conditions used as said crystallized material conditions should be determined strictly.

[0083]It is very good in a step cooling method which controls hardening finish temperature to the relatively high temperature of 60 - 130 **, and is held at this temperature for 0.5 to 48 hours as shown in JP,1-111851,A, without performing hardening at the time of solution treatment to a room temperature. Final heat treatment of 8 to 36 hours may be performed at the temperature of 40 - 120 ** within 72 hours after solution-heat-treatment hardening as shown in JP,5-7460,B. These processings can raise the baking hardenability at the time of paint printing, i.e., the proof stress after paint printing.

[0084]
[Example]Next, the example of this invention method is described. Table 1 uniformity heat treatment was performed for the aluminum-Mg-Si system aluminum alloy ingot (50-mm thickness) which is alike and has the chemical composition of this invention within the limits to No.1-9 shown in the range of 535 **x8 time after the ingot by the direct chill casting process. And while making rolling starting temperature into 500 **, by 300 **, rolling was ended and it hot-rolled to 2.5 mm in thickness. Next, the cold rolling rate performed 60% of cold rolling to process annealing and 1.0 mm in thickness by 500 **. Then, after carrying out solution treatment in the range of 530 **, it is water quenching to a room temperature. (a part for hardening speed 600 **/) The Al alloy sheet carried out was made into the test specimen, and it produced as example Noof invention .1-9 shown in Table 2. Only example Noof invention.9 performed the processing with other same manufacturing conditions which suspends hardening after solution treatment at 70 ** but, holds for 48 hours and ****** after that at this temperature.
[0085]It is proof stress, as a result of performing tensile strength of the test specimen after neglect for 90 days at the room temperature after said solution-heat-treatment

hardening and doing a tensile test by the JIS Z 2241 method. ($sigma_{0.2}$) It was more than 120-N[/mm] ^{2}. (a tensile direction is [as opposed to / in addition / LT= rolling direction] the direction of 90 degree) . Proof stress after the proof stress after bake corresponding after paint baking performs heating for after [a 2% stretch] 170 **x 20 minutes ($sigma_{0.2}$) It measured. These results are shown in Table 2.

[0086]As shown in Table 2 using the aluminum alloy in which No.10 of Table 1 and the presentation shown in 11 separated from this invention range for comparison, Manufacturing conditions manufactured comparative example No.10 in which the average interval between the pitch diameter of an aluminum-Fe system and Mg_2Si crystallized material and/, or this crystallized material or the pitch diameter of the aluminum-Mn system particulate material separated from regulation, and 11 as fundamentally the same with the example of an invention.

[0087]A presentation is this invention within the limits of No.12 of Table 1. Although it was considered as the aluminum alloy and manufacturing conditions were also made into the same conditions as the example of an invention, As compared with a part for 200 **/, and the example of an invention, since it was late, crystallized material of hardening speed by water quenching after solution treatment increased in number, and the average interval between crystallized material produced comparative example No.12 which became small just like conventional technology. A presentation is No.3 (example of an invention) of Table 1. Although it was the same and manufacturing conditions were also made into the same conditions as the example of an invention, Hardening after solution treatment is air cooling. (a part for 10 **/in hardening speed) Since hardening speed was slow, crystallized material increased in number, and other conditions produced like the example comparative example No.13 to which the average interval between crystallized material became small just like conventional technology.

[0088]And it is an average crystal grain diameter of a recrystallization grain at the measuring condition by the 50 times as many optical microscopes which extracted the specimen respectively from said test specimen, and were described above. (micrometer) It asked. It is a pitch diameter of an aluminum-Fe system and Mg_2Si crystallized material at the measuring condition by the scanning electron microscope (SEM) of one times the above mentioned magnification of 500. (micrometer) Average interval between these crystallized material (micrometer) It asked. It asked for the pitch diameter of an aluminum-Mn system particulate material, and the number per unit volume by the measuring condition by the 5000 times as many above mentioned transmission electron microscopes (TEM). These results are shown in Table 2.

[0089]And an Al alloy sheet is neglected for a long period of time, and carries out room temperature prescription, and it imitates that press forming is carried out as said outer panel of a car after that, Deep-drawing shaping was carried out by having used the test specimen after neglect as the blank material for 90 days at the room temperature after said solution-heat-treatment hardening, and it asked for the maximum diaphragm depth (LDH_O) currently fabricated without producing a crack in that case. These results are also shown in Table 2. The conditions of deep-drawing shaping are inside diameter

52.8mmphi (outer diameter 220mm phi) at a punch with a diameter [phi] of 50.0 mm and shoulder R5.0mm in shoulder R5.0mm. A dice is used and it is a dice. The crevice during a wrinkles presser foot was performed on the conditions kept constant with the SIMM of the same thickness as a blank material.

[0090]An Al alloy sheet is neglected for a long period of time, and carries out room temperature prescription, and they are bend radii (R) as said outer panel of after that and a car. Board thickness (t) A ratio (R/t) is 3.0. The following bendings (flat hem processing) The bending test which imitated being carried out was done. That is, the bending test was done after performing 5% of stretch after neglect for 90 days at the room temperature after said solution-heat-treatment hardening. 3 as which bending test conditions are specified to JIS Z 2204 The bending test of the test piece for bend test by the V-block bend method specified to JIS Z 2248 shall be done using an item specimen with the pressing bend method to which it is specified further JIS Z 2248. It is a situation of a crack of the bending part surface of the specimen after an examination 5 Visual observation was carried out with the magnifying glass of twice as many magnification as this. As a result, it was considered as x noting that what generated neither a crack of recessed shape nor dry rough skin on the bending part surface was made into O, the crevice had occurred on the bending part surface and the crack generated that by which the new field was observed by the maximum pars basilaris ossis occipitalis of this crevice. It is estimated that dry rough skin generated that by which a new field is not observed at the maximum pars basilaris ossis occipitalis of said crevice. These results are also shown in Table 2. Even if it compares with other bending tests specified to JIS Z 2248, said bending test method specified by this invention is the severe examining method, while corresponding well with a actual hem working result.

[0091]It is 2 by the spray painting after performing cathodic electrodeposition coating after zinc phosphate processing for these test specimens that carried out deep-drawing shaping. Coat 2 The coating film of bake was provided. 2 Coat 2 As middle-coat paint, the coating film of bake provides the polyester melamine system coating film of 30-micrometer thickness, and perform it, and also baking for 140 **x 20 minutes as finish coating, The polyester melamine system coating film of 30-micrometer thickness was provided, and baking for 180 **x 20 minutes was performed.

[0092]And the thread-proof rust evaluation test was altogether done on the paint specimen of the example of these inventions, and the comparative example on the same conditions. These evaluation results are also shown in Table 2. After a piece gives the cross cut which is 7 cm to the hide material side surface of a paint specimen in a thread-proof rust evaluation test, 35 ** 3%HCl solution -- 2 -- neglecting it subsequently to the atmosphere of the homoiothermal constant humidity of 40 ** and 85%RH for 1500 hours, after being immersed between parts -- length-between-couplings [of the thread rust which acted as a late-coming student] L (crosscut more vertical distance) It measured. And for comparison, phosphate treating and an ED painting coat, the still more nearly same middle coat, and finish coating were performed to Table 1 and the aluminum alloy specimen of comparative example No.11 of 2, length-between-couplings L of the thread rust generated in this specimen was set to 1, and it was estimated in comparison

with this as O:L<=0.5 and x:L>=1.

[0093]Table 2 While an Al alloy sheet contains Mg:0.2-1.6%, Si:0.2-1.8%, and Mn:0.01-0.15% as [clear] ** et al., It has the basic composition which regulated Fe below 0.15%, and the average crystal grain diameter of the recrystallization grain in the microstructure after solution treatment is 45 micrometers or less, While the pitch diameter of an aluminum-Fe system and Mg_2Si crystallized material is below 5 mum, the average interval between these crystallized material is not less than 20 micrometers, And while the pitch diameter of an aluminum-Mn system particulate material is 0.02 - 0.8 mum, the number per unit volume is 1. Example Noof invention .1 which is an individual / more than mum^3 - 9, Proof stress of the Al alloy sheet by which a fabricating operation is carried out ($sigma_{0.2}$) It is a press even if high. (deep drawing) It turns out that it excels in a moldability and hem workability.

[0094]It turns out that the example of these inventions is notably excellent to thread-proof rust nature also in respect of the corrosion resistance after paint. As compared with the comparative example which mentions this reason later, the example of an invention has a large interval between crystallized material, and, for this reason, is estimated that propagation of the thread rust formation itself or the generated thread rust is controlled.

[0095]On the other hand, the pitch diameter of an aluminum-Fe system and Mg_2Si crystallized material and/, or the average interval between these crystallized material, Or it turns out that the pitch diameter of an aluminum-Mn system particulate material is inferior to press-working-of-sheet-metal nature and hem workability in comparative example No.10 which separated from regulation - 13 remarkably as compared with the example of an invention. It turns out that these comparative examples are inferior to thread-proof rust nature also in respect of the corrosion resistance after paint.

[0096]also in this comparative example, as for comparative example No.13, although basic composition satisfies this invention, there is a problem in a manufacturing method, especially solution treatment conditions (air cooling -- a cooling rate -- late) The average interval of an aluminum-Fe system and Mg_2Si crystallized material is small. Therefore, in order to satisfy regulation of this invention crystallized material and a particulate material from this fact, it is proved that it is necessary to choose strictly not only the presentation of an aluminum alloy but manufacturing method conditions.

[0097]furthermore -- it should mention especially -- it is comparative example No.12, and although, as for comparative example No.12, basic composition satisfies this invention and water quenching is carried out within the limits of desirable manufacturing conditions after a manufacturing method, especially solution treatment, the average interval of crystallized material is small. Since this contains many (0.60%) Cu(s) comparatively as a presentation, even if a part for 200 **/and hardening speed are large (comparing with air cooling) The average interval of an aluminum-Fe system and Mg_2Si crystallized material is small. Such a phenomenon may happen, when [other than Cu] the amount of Si is comparatively high. Therefore, these facts show that regulation of crystallized material thru/or a particulate material may be unable to be satisfied, even if

basic composition and manufacturing conditions are this invention within the limits. For this reason, in order to satisfy regulation of this invention crystallized material and a particulate material, it is proved that it is necessary to choose manufacturing conditions strictly according to selection of a presentation of an aluminum alloy.

[0098]From the above example, as a panel material for transport airplanes, such as a car and vehicles, This invention which may be satisfied both press-forming nature and hem processing especially, A specific meaning of Mn and a Fe amount, the meaning of average crystal grain diameter specification of the recrystallization grain in the microstructure after solution treatment, and the meaning in which an aluminum-Fe system, Mg_2Si crystallized material, and an aluminum-Mn system particulate material are still more specific are supported. And the necessity that specification of the crystallized material of these this inventions and the organization of a particulate material is independently specified as a presentation and manufacturing conditions of an aluminum alloy is also supported.

[0099]

[Table 1]

略号	Al合金の化学成分 (mass%、但しB, BeはppBeはppm)													備考
	Si	Fe	Cu	Mn	Mg	Cr	Zn	Zr	V	Ti	B	Be	残部	
1	0.51	0.05	0.01	0.06	1.0	—	—	—	—	—	—	—	Al	6061相当（発明例）
2	0.80	0.06	0.01	0.08	0.76	0.20	—	—	—	0.01	—	—	Al	6N01相当（発明例）
3	1.10	0.15	0.35	0.06	0.65	—	—	—	—	0.01	—	—	Al	6151相当（発明例）
4	0.99	0.05	0.01	0.05	0.80	—	—	—	—	0.01	—	—	Al	6151相当（発明例）
5	1.10	0.08	0.01	0.05	0.65	0.20	—	—	—	0.01	30	—	Al	6151相当（発明例）
6	0.51	1.0	0.01	0.06	0.82	—	0.1	0.11	—	0.01	—	—	Al	6061相当（発明例）
7	1.10	0.08	0.01	0.08	0.65	0.20	0.1	—	0.12	0.02	30	—	Al	6151相当（発明例）
8	0.51	0.05	0.60	0.06	0.82	0.20	—	—	—	0.01	—	50	Al	6061相当（発明例）
9	1.10	0.04	0.01	0.10	0.55	—	—	—	—	0.01	—	—	Al	6151相当（発明例）
10	1.10	0.08	0.01	0.40	0.65	0.20	0.1	0.11	—	0.04	—	—	Al	Mn上限越え（比較例）
11	1.00	0.35	0.01	0.06	0.82	0.14	—	—	—	0.01	—	—	Al	Fe上限越え（比較例）
12	1.05	0.12	0.60	0.05	0.50	—	—	—	—	0.01	—	—	Al	6151相当（発明例）

[0100]

[Table 2]

略号	区分	溶体化処理後のミクロ組織					Al合金板の特性					
		平均結晶粒径	Al-Fe 系晶出物および Mg_2Si 晶出物		Al-Mn 系などの分散粒子		焼付硬化前				焼付硬化後	
		(μm)	平均径 (μm)	平均間隔 (μm)	平均径 (μm)	個数/単位体積	耐力 $\sigma_{0.2}$ (N/mm^2)	伸び δ (%)	LDH_0 (mm)	ヘム加工性	耐力 $\sigma_{0.2}$ (N/mm^2)	耐糸さび性
1	発明例	40	2.2	30	0.13	1.8	140	30	25.0	○	155	○
2	発明例	35	2.5	30	0.15	5.0	125	31	25.5	○	160	○
3	発明例	30	3.0	25	0.15	3.0	140	33	27.0	○	175	○
4	発明例	40	2.0	28	0.12	2.0	145	35	28.5	○	180	○
5	発明例	30	2.5	26	0.18	4.5	125	32	26.5	○	165	○
6	発明例	28	3.3	27	0.15	7.0	120	30	25.0	○	170	○
7	発明例	30	3.0	30	0.16	5.0	140	32	26.5	○	165	○
8	発明例	40	2.3	30	0.15	4.0	150	30	25.0	○	180	○
9	発明例	40	1.8	35	0.18	3.5	135	30	25.0	○	205	○
10	比較例	30	3.0	22	0.90	5.0	145	28	24.0	×	175	×
11	比較例	25	5.5	15	0.30	1.5	130	26	23.0	×	160	×
12	比較例	35	4.0	10	0.15	3.0	120	29	24.5	×	140	×
13	比較例	42	5.2	16	0.14	2.0	145	29	24.5	×	165	×

[0101]
[Effect of the Invention]According to this invention, while having the higher tensile strength for the weight saving of a transport airplane, and high proof stress, the use of an Al alloy sheet is greatly expanded at the point which enabled offer of the Al alloy sheet which has the outstanding deep-drawing moldability and hem workability, and industrial value is large.